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THE EFFECT OF MILLIMETER WAVES ON THE MICROFLORA IN ROOM AIR

by

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Abstract

Results are given of an experimental investigation of the possibility of the sterilizing action of millimeter waves on microflora in the air of a laboratory room. The dependence of the bactericidal effect of electromagnetic fields in the millimeter range on wavelength and on irradiation time is demonstrated.

I. INTRODUCTION

The literature contains information on the bactericidal and bacterial static action of the electromagnetic fields over a wide range of radiofrequencies--from low frequencies to microwave frequencies [1-7]. The results are obtained mainly for radiation of bacteria which are situated in a liquid medium (in the form of a microsuspension).

The effect of the electromagnetic fields in the millimeter range on air microflora began to be investigated comparatively recently. As a result of the investigations, a reduction in the number of bacteria in air was detected when a millimeter-wave oscillator was in operation.

The present paper is devoted to investigating the effect of an electro magnetic field in the millimeter range of wavelengths on the microflora in

the air of a laboratory room for the purpose of clarifying the possibilities of the bactericidal action of millimeter waves.

2. THE EXPERIMENTAL PROCEDURE

In order to irradiate the microflora in the air of a laboratory room having a volume of 50 m^3 a backward-wave tube of BOB-612 type operating in a continuous-wave mode was used. The dispersion characteristic of the tube is shown in Fig. 1. The wide range of electronic tuning of the tube (5.7 to 8.0 mm) allows only an oscillator to be used to investigate the effect of various frequencies on the microflora in the air.

At the required frequency the tube was tuned by varying the voltage across the slow-wave system. The wavelength was measured by a tune wave meter within 0.3%. The power was measured by means of a thermistor bridge connected at the output of microwave path through a calibrated attenuator. The power was monitored during the measurement process by means of an indicator connected through a directional coupler. The magnitude of the power fluctuations during the experiment did not exceed 10%.

A diagram of the unit is illustrated in Fig. 2. (Insert Figs. 1 and 2, RP 133, Fig. 1 - Dependence of the Wavelength on the Voltage Across the Slow-Wave System; Fig. 2 - Block Diagram of the Unit for Irradiating the Microflora in the Air)

The irradiation of the microflora in the air of the room was carried out at various wavelengths (5.7 to 7.1 mm) from the open end of a standard waveguide having a cross-section of 2.6 x 5.2 at an approximately identical power level (a power of approximately 100 mW).

The working ventilator (with a productivity of 40 m^3/h) and convection created a continuous change in the air entering the irradiation zone.

(Footnote bottom of RP 134)

* A Czech modification of the Krotov instrument was used--the Chirana type S aeroscope.

** The figure shows the results of experiments with and without irradiation, averaged over five measurements. The investigations were performed at a wavelength of 6 mm.

The over-all bacterial seeding of the air was studied. The investigations were carried out by two methods simultaneously--by the sedimentation method (the Koch cup method) and the aspiration method (using a device of the Krotov*-instrument type). The samples were taken at various points of the room at distances of from 2 to 5 m from the radiation source. A 4% meat-peptone agar was used as the nutrient medium. The exposure time of the cups in the sedimentation method lasted 30 min, while in the aspiration method it lasted 1 min. During this time approximately 45 to 50 liters of air passed through the instrument.

The collection of the samples (from several cups in each method) was carried out before irradiation and then every 30 min after the oscillator had been turned off for a period of 2 to 4 hr. In certain cases an additional sample was taken 15 min after the beginning of irradiation. Petri cups with the seeding were placed into a thermostat at a temperature of 37°C for 24 hr. Then during the period of a day they were held at room temperature, after that the number of colonies of microorganisms that had grown was counted. The average results obtained from several parallel samples (separately according

to the sedimentation and aspiration methods) were calculated. The data from the aspiration method was used to calculate the number of bacteria 1 m^3 of air. The movement of people in the room was restricted during the experiment. The temperature, humidity and atmospheric pressure were recorded.

3. THE RESULTS OF THE INVESTIGATION

The effect of millimeter wave on the microflora of the air in a room was investigated:

--as a function of the duration of irradiation for a constant wavelength and constant power;

--as a function of the wavelength for constant power and the same irradiation time.

The experiment showed that when a room is irradiated with millimeter waves the number of bacteria in the air is reduced radically, especially during the first hour (Fig. 3**, Curve 1). The number of bacteria after 1.5 hr of irradiation is decreased significantly; it is difficult to determine the further change in the number of bacteria reliably using the adopted method.

In order to compare the efficiency of the irradiation and to introduce corrections for natural precipitation of bacterial aerosol, control experiments were carried out without irradiation) under the same conditions. The decrease in the number of microorganisms in the air of a closed room in the control experiment is smoother (Fig. 3, Curve 2).

During the experiments it was discovered that the bactericidal action of millimeter waves is not identical in the interval of 5.7 to 7.1 mm. Several maxima and minima were observed. (Insert Figs. 3 and 4, RP 135; Fig. 3. Reduction of the Number of Microorganisms in the Air of a Laboratory Room as a Function of Time (Sedimentation Method); (1) Experiment With Irradiation (λ = clst, P = const); (2) Control Experiment Without Irradiation; S_{irr}/S_o--ratio between the number of microorganisms after irradiation as the original number. Fig. 4. Dependence of the Batericidal Action of Millimeter Radiation on Wavelength: (1 and 2) Experiment With Irradiation (P = 100 mW, irradiation time 1 hr); (3 and 4) Control Experiment Without Irradiation; the Solid Curves Correspond to the Aspiration Method, and the Dash Curves Correspond to the Sedimentation Method.

(Footnote bottom of page RP 135)

* Curves 1 and 2 represent the results of several measurements at each point. Curves 3 and 4 are the average data for five control experiments without irradiation, which characterize the magnitude of the reduction in the concentration of microorganisms in the air in 1 hr associated with the natural precipitation of particles of bacterial aerosol.

Figure 4* shows the dependence of the bactericidal action of millimeter waves on wavelength in the 6.3 to 6.9 mm (the irradiation time was 1 hr, and the power was approximately 100 mW). The intervals of shorter wavelengths (5.7 to 6.3 mm) and longer wavelengths (6.9 to 7.1 mm) were not adequately investigated. Here maxima and minima of the efficiency were likewise observed,

but the individual points were obtained as a result of single measurements and require further refinement. Therefore, the curves for this interval are not shown in the figure.

4. CONCLUSIONS

As a result of the work which was carried out, the following has been established:

(1) Millimeter waves exert a bactericidal action with regard to the microflora in the air of a laboratory room;

(2) The efficiency of the bactericidal action depends on wavelength and irradiation time.

The results obtained register the main character of the effect of which millimeter waves have on microorganisms, but they also require refinement, since many extraneous factors are superimposed on the characteristics of pain in a room: the magnitude of the original bacterial background, the change in the quantitative composition of the microorganisms due to natural precipitation and reverse diffusion of bacterial aerosol, change in the qualitative composition of the microflora, fluctuations of the humidity and temperature of the air, movement of people in the room, and others. Many questions may be refined by performing work on pure bacterial cultures. From this point of view, work which has been done may be treated as the first stage of a large cycle of investigations.

LITERATURE CITED

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